In : Lee, Jeffrey A. and Zobeck, Ted M., 2002, Proceedings of ICAR5/GCTE-SEN Joint Conference, International Center for Arid and Semiarid Lands Studies, Texas Tech University, Lubbock, Texas, USA Publication 02-2 p. 325

Regional Evaluation of Wind Erosion from Loess Lands: A Case Study of Pengyang County, Ningxia, China

Yubao Li, Inner Mongolia Agricultural University, China (li_yob@hotmail.com)

E. L. Skidmore, USDA-ARS, Wind Erosion Research Unit, Kansas State University, Manhattan, Kansas 66506 (skidmore@weru.ksu.edu)

Baoping Sun, Beijing Forestry University, China (sunbp@mail.bjfu.edu.cn)

Introduction

The Loess Plateau in China is notorious for severe soil erosion by water. Soil erosion on the Loess Plateau contributes 80% of the annual sediments of 1.6 billion tons into the Yellow River(Liu,1985). Recently, a nationwide soil erosion survey recognized that wind erosion from loess lands is a serious problem. Creep and saltation sediments from croplands and grasslands collect in gullies during the wind erosion seasons, and are then carried into rivers during the rainy seasons. So, wind erosion in loess region not only degrades land resources and pollutes local and off-site atmospheric environments, but also contributes sediments into rivers.

Zobeck at al.(2000) identified four problems that may exist in the use of field models and GIS: assumption of homogeneity, methods to derive the attribute values needed, merging data, and scale differences. Most current wind erosion models simulate an isolated homogeneous field (Hagen,1991). The influences of sand-borne flow from upwind field are hard to estimate when it is scaled up. Evaluation of wind erosion on a regional scale in China is still a challenge. The objective of the project was to determine erosion severity for each land use according to The National Standard for Soil Erosion Classification (China Ministry of Water Resources, 1994), using Pengyang County, Ningxia as an example.

Methods

Pengyang County, located in south Ningxia Autonomous Region, China, is a semiarid region with an annual precipitation of 490mm, and average annual temperature of 5.3°C. The region has

Table 1 Classification criteria for soil erosion severity as a national standard

Grades	*Average erosion modulu*	*Average erosion dep*
	—— Ton km-2 yr-1 ——	—— mm yr-1——
1 Tolerable(Trace)	<200	<0.15
2 Slight	200-2500	0.15-1.9
3 Medium	2500-5000	1.9-3.7
4 Severe	5000-8000	3.7-5.9
5 Very severe	8000-15000	5.9-11.1
6 Extremely severe	>15000	>11.1

an average of 24 days of gale (≥17m/sec.) and signs of soil blown by wind can be observed on some barren croplands in spring. Its total land area is 2524.7 km^2 and total soil area is 2389.2 km^2, in which 93.3% is covered by loess (Wang,1990). There are four soil groups in the region, Heilu, Loessal and Alluvial soils have developed from loess materials and Gray Cinnamon Forest soil is distributed in mountainous areas. The loess in the region is several to two hundred meters deep with gully density of 1-3 km/ km^2. As parent material, loess includes two major mineral constituents, quartz (49-64%) and feldspar (30-43%). Lime content is as high as 8-16%. Soil grain size composition is 17.0-24.0% of 0.25-0.05mm, 56.0-61.5% of 0.05-0.01mm, 6.0-7.5% of 0.01-0.005mm, 5.5-6.0% of 0.005-0.001mm and 8.0-8.5 of <0.001mm. The regional wind erosion evaluation is based on The National Standard for Soil Erosion Classification (Table 1) issued by China Ministry of Water Resources (China Ministry of Water Resources, 1994). Grasslands and croplands were evaluated separately. The SQL language was used to execute evaluation regulations in GIS environment.

GIS Database of Land Use

A GIS database is essential to regional wind erosion evaluation. Processed scenes of Landsat Thematic Mapper(TM) images of Ningxia (July,1996) and Ningxia Land Use Map provided by the Remote Sensing Institute of Chinese Academy of Sciences are base maps. Ningxia Relief Map (1:100,000), the Soil Type Map (1:350,000) and Vegetation Map (1:500,000) were consulted as references when completing the GISdatabase. For each land use, we added fields including geomorphological element, soil group and subgroup, annual precipitation and gale days, autumn and summer crop type, and irrigation. The database and base map is established in ARC/INFO geographical information system. Region Manager, a geographic information system specialized in water and soil conservation planning was employed to realize evaluation regulations(Shi and Sun, 1996). Field validations were conducted in July and October of 1999 and April and June of 2000.

Evaluation Indicator System

Factor systems selected as indicators to evaluate erosion intensities are different between grassland and cropland. Classification of these indicators was shown in Table 2. Erodible Fraction was added latter as an indicator. Grains less than 0.84mm in diameter were defined erodible. Erodible fraction referred to the percentage of erodible particles in the surface soil. Eighteen soil samples from 6 land types collected within 5 mm were directly sieved on the sites in October 15 of 1999, using a shovel to collect dry surface soil, then weighted in laboratory after air-dried. The sieves were manually operated. Each natural soil sample was around 5 kg.

Table 2 Indicators and their gradation for wind erosion evaluation

Indicators	Grades classified
Vegetation Coverage(%)	High: >70, medium: 70-30, low: <30
Erodible Fraction(%)	<30, 30-40, >40
Landforms	
low land:	gully, valley, lower slope and small basin;
high land:	high table, hilltop and middle and upper slope
Farming Management	
Irrigation	irrigated, nonirrigated
Crop Type	autumn, summer
Windbreak	arbor, shrub, none

Erosion Severity Ranges in the Region

Plowed and harrowed cropland was defined as the most erodible in terms of the condition of vegetation, roughness and aggregation. Precipitation and the gale days in 1999 were 442.6 mm and 31 days, which were slightly drier and windier than the recent 10-year average. Three pieces of dry croplands in Pengyang County, Ningxia were selected to measure the soil loss from October 15th,1999 to May 20th, 2000(An erosive rain event occurred on May 26). Two hundred and fifteen metal rods (200mm long and 5mm in diameter) with millimeter marks were put vertically in the 3 pieces of lands. Each rod occupied an area of 3m×3m, evenly distributed in the lands.

Field observations by Sun and Li were conducted in April and June 2000. For the least erodible lands, erosion severity of Trace (average erosion modulus less than 200 Ton km^{-2} yr^{-1}) were determined according to: 1) if wind erosion signs or tracks could be found, and 2) if sediments in gullies and furrows around the lands could be observed.

Results and Discussion

Land Types and Land Use Types

To meet the needs for regional evaluation of wind erosion intensity, the land use type classification system included 3 hierarchies. The first class separated grassland and cropland from others. The second is small landform, basically including slopes and gullies. The third covered information of vegetation coverage or cropping. As shown in Table 3, croplands occupied more than 70% of the total land area of the county, among which 72% was slope farmlands. In total, 125 polygons were validated. Interpretation error is 27.3%. The classifications of geomorphological forms and crop types presented the majority of total error.

Table 3 Areas for land types and land use types in 1999 of the Pengyang County.

Land use type	*Area*		Land use type	Area	
	---hm^2---	--%--		---hm^2---	--%--
TOTAL	252466.7	100	2 cropland	178,600.0	70.7
1 Grasslands	55,200.0	21.9	2.1 slope	129306.4	51.2
1.1 gully	16339.2	6.5	2.1.1 summer crop slope	41378.1	16.4
1.1.1 high grass gully	1470.5	0.6	2.1.2 autumn crop slope	87928.3	34.8
1.1.2 medium grass gully	5882.1	2.3	2.2 valley	49293.6	19.5
1.1.3 low grass gully	8986.6	3.6	2.2.1 summer crop valley	8379.9	3.3
1.2 hilltop	38860.8	15.4	2.2.2 autumn crop valley	32876.7	13.0
1.2.1 high grass hilltop	3497.5	1.4	2.2.3 irrigated valley	8037.0	3.2
1.2.2 medium grass hilltop	19819.0	7.8	3 others	18,666.7	7.4
1.2.3 low grass hilltop	**15544.3**	**6.2**	3.1 forest	2666.7	1.1
			3.2 water	2666.7	1.1
			3.3 others	**13333.3**	**5.2**

Erosion severity evaluation

As supposed, the plowed and harrowed croplands have more erodible particles in surface layer (Table 4). The average erosion depth from the tested croplands was 3.19 mm, falling into Medium erosion severity. So wind erosion severity for all the lands in the estimated region is between Trace to Medium. The field observation determined that the slightest grade of severity, Trace included 7 land use types, accounting for 23.1% of the total soil area while the severest grade, Medium, occupied 34.8%.

Table 4 The results of wind erosion severity evaluation for Pengyang County.

Erosion intensity	Land types	Erodible frac	Management	Area
		---%---21.3		---hm^2---147
1 Tolerable(Trace)	1.1.1 high grass gully	24.5	Grazing	5882.1
	1.1.2 medium grass gully	23.6	Grazing	8986.6
Area: 58322.4 hm^2	1.1.3 low grass gully	21.3	Grazing	3497.5
Percent: 23.1%	1.2.1 high grass hilltop	24.5	Grazing	19819.0
	1.2.2 medium grass hilltop	--	Grazing	2666.7
	3.1 forest	--	--	2666.7
	3.2 water	--	--	13333.3
	3.3 others		--	
2 Slight	1.2.3 low grass hilltop	23.6	Grazing	15544.3
	2.1.1 summer crop slope	29.5	Plowed in early autumn	41378.1
Area: 106216.0 hm^2	2.2.1 summer crop valley	29.5	Plowed in early autumn	8379.9
Percent: 42.1%	2.2.2 autumn crop valley	46.0	Plowed in late autumn	32876.7
	2.2.3 irrigated valley	32.1	Plowed in late autumn	8037.0
3 Medium	2.1.2 autumn crop slope	46.0	Plowed in late autumn	87928.3
Percent: 34.8%				

In : Lee, Jeffrey A. and Zobeck, Ted M., 2002, Proceedings of ICAR5/GCTE-SEN Joint Conference, International Center for Arid and Semiarid Lands Studies, Texas Tech University, Lubbock, Texas, USA Publication 02-2 p. 329

Conclusions

RS and GIS technologies were employed to evaluate wind erosion severity from loess soils on a regional scale. The results show that wind erosion from traditionally managed dry croplands is a problem in the studied region. A GIS database proved essential to regional evaluation of soil erosion. Field observations to determine the ranges of erosion severity from the most and least erodible lands may improve personal subjectivity from experts' evaluation system.

References

China Ministry of Water Resources, 1994. The National Standard for Soil Erosion Classification. Water Conservancy Press. Beijing, China

Shi, Mingchang& Baoping Sun 1996. GIS Aided Expert Model of Land Evaluation(in Chinese), 18,50-56

Hagen,L.J.(1991). A wind erosion prediction system to meet user needs. *Journal of Soil and Water Conservation*, 46(2): 106-111

Liu Dongsheng et al. The Loess and the Environment(in Chinese). Beijing: Scientific Press, 1985, 42

Wang, Jizhi(Ed) 1990. Ningxia Soil(in Chinese). People's Press of Ningxia, Yinchuan

Zobeck, T.M., N.C. Parker, S. Haskell, K. Guoding 2000. Scaling up from field to region for wind erosion prediction using a field-scale wind erosion model and GIS. *Agriculture, Ecosystem and Environment* 82,247-259